Rainfall Reconstruction using Speleothems from Indian Subcontinent

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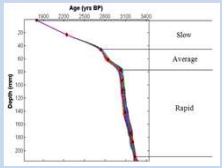
Sampling and Method

A speleothem sample from the Kadapa cave, Andhra Pradesh, India has been collected in 2013, aimed to high resolution rainfall reconstruction for the peninsular India. Some more samples were collected from Andaman Island, Andhra Pradesh and Meghalaya regions in 2014, 2016 and 2018, respectively.

- Stalagmite was cut along the growth axis using a diamond band saws cutter (DRAMET-BS270).
- Micro-mill sampling system (New Wave Research) was used to extract carbonate samples with a spatial resolution of 150µm. 1134 samples have been extracted for isotopic measurements from a ~22cm long Kadapa stalagmite sample.

Oxygen Isotopes, XRD, Trace Elements Analyses and U-Th Dating



- Samples were analyzed on a delta V plus IRMS for $\delta^{18}O$ and $\delta^{13}C$ with precision better than 0.1‰ at IITM. Laboratory standards NBS-19 and Physical Research Laboratory (PRL, Makrana Marble) were run along with samples to check the reproducibility and accuracy of the measurements.
- Approximately 1 mg sub-samples were extracted from 6 different layers for X-ray diffraction (XRD) analyses to ascertain the calcite and aragonite proportions in the sample. The measurements were carried out on Bruker Powder XRD at the Indian Institute of Science Education and Research, in Pune.
- Samples for Trace Elements were analysed using Thermo X-series II ICP-MS at University of Queensland, Australia.
- A precise chronology of the samples was established using U-Th dating by MC-ICPMS at Universityof, Australia.

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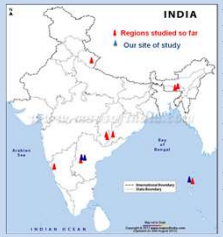
Introduction

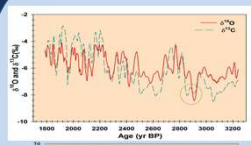
In order to reconstruct the past monsoon variability, oxygen isotopic records from cave deposits such as, speleothems from Indian subcontinent has widely been used.

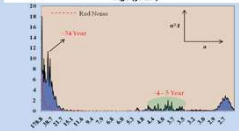


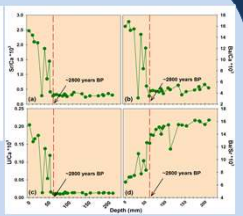
- 5700-14700 BP (Kurnool, AP; Lone et al, 2014; *PALAEO3*)
- 11200-3670 BP (Meghalaya; Berkelhammer et al, 2012; *AGU Monograph*)
- Present-4000 BP (Andaman; Laskar et al, 2013; G3)
- Present-3400 BP (Chhattisgarh; Yadava and Ramesh 2005; *The Holocence*)
- AD 600-1500 (Chhattisgarh; Sinha et al, 2007; *GRL*)
- AD 1075-2008 (Chhattisgarh; Sinha et al, 2011; *GRL*)
- AD 1399-2007 (Shillong; Sinha et al, 2011; *GRL*)
- AD 1560-2006 (Uttarakhand; *Kotlia et al, 2012; Quaternary International*)
- AD 1666-1996 (Karnataka; Yadava et al, 2004; *The Holocence*)

Indian summer monsoon (ISM) exhibited variability on a various time scales and its association with atmospheric and oceanic conditions affect the monsoonal circulation over the India. Furthermore, teleconnection between ISM and large circulations are also been revealed. Despite these efforts, several global as well as regional climatic events are yet to be seen in the Indian land records.

Results

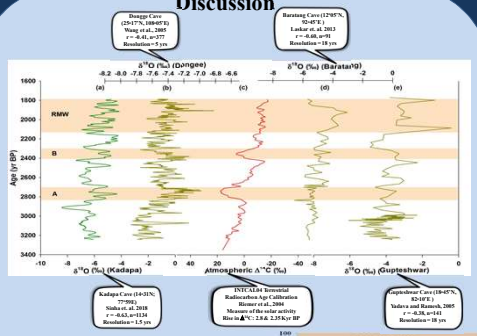


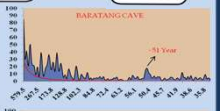


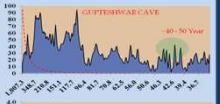


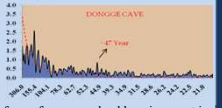
- Resolution is one of the best from the Indian region (Avg ~1 yr) so far.
- The Kadapa stalagmite record captures variations associated with wet and dry monsoons on decadal to centennial time-scales, together with a general declining trend in the ISM during the 1460 year period. The $\delta^{18}O$ showed an overall declining trend in rainfall (ca, ~ -1.8‰).
- The $\delta^{18}O$ record revealed evidence of abrupt climate change around 2800 yr BP.
- Sr/Ca, Ba/Ca and U/Ca show significant variations along the growth axis of stalagmite. The average value of the Ba/Sr ratio for the period 1720-2800 yr BP is 8.2±1.5 and it sharply changes to 14.7±1.3 between 2800-3180 yr BP
- Higher $\delta^{18}O$ values around 2800 yr BP are corroborated by changes in the stalagmite growth rate, its trace elemental ratios (Sr/Ca, Ba/Ca and U/Ca) and crystallographic structure .
- ~50 yr periodicity found in 1460 yr Kadapa record.

Discussion









- A general declining trend in the ISM is observed in all the speleothem records. The overall declining trend in the ISM rainfall seems to be associated with the southward migration of the ITCZ, associated with lower northern hemispheric summer insolation during the study period
- The coherency between the Kadapa and Dongge cave is also observed. This points towards the synchronous behavior of the ISM and East Asian Monsoon.
- Large $\delta^{18}O$ depletions at around 2900 yr BP correspond to major heavy rain events associated with intense cyclonic activity in the Bay of Bengal.
- There is a marked similarity in an abrupt rise in $\Delta^{14}C$ and the associated decline in monsoon activity, particularly for the period around 2350 and 2800 yr BP. XRD and trace metal analyses also indicate the change in Kadapa cave environment at ~2800 yr BP.
- Similar abrupt climatic change at ~2800 yr BP, in the form of an unusual cold environment in the North Atlantic and continental Europe triggered by a decline in solar activity, has been widely reported.
- The record displays several notable wet and dry periods on multi-decadal to centennial scales. This also shows drier conditions intercepted with the short wet spells during the Roman Warm Period, which lasted for several centuries.
- Caves record corroborate the existence of multi-decadal oscillations (~50 yr) in the Asian monsoon. Other proxies from Pacific also suggest existence of ~50-90 yr periodicity in the ENSO activity (Li et al., 2011).
- Multi-decadal oscillations in the ENSO amplitude may causing the variation in its relationship with the Indian monsoon.

Acknowledgments

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